NASA

National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas 77058

(NASA-CR-167379) SPACE SHUTTLE AFRSI LARGE-SCALE DEVELOPMENT TEST USING MODEL 117-0 SPECIMENS AND MODEL 81-0 TEST FIXTURE IN THE AMES RESEARCH CENTER 9 X 7 FOOT SUPERSONIC WIND TUNNEL (OS302B) (Chrysler

N82-77335

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SPACE SHUTTLE
AERODYNAMIC DATA REPORT

Data ManAGEMENT SERVICES

HUNTSVILLE ELECTRONICS DIVISION CHRYSLER CORPORATION

June 1982

DMS-DR-2504
NASA-CR 167,379

SPACE SHUTTLE AFRSI LARGE-SCALE DEVELOPMENT TEST USING MODEL 117-Ø SPECIMENS AND MODEL 81-Ø TEST FIXTURE IN THE AMES RESEARCH CENTER 9x7-FOOT SUPERSONIC WIND TUNNEL (OS302B)

by
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Space Transportation Systems Group

Prepared under NASA Contract Number NAS9-16283

by

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for

Engineering Analysis Division

Johnson Space Center
National Aeronautics and Space Administration
Houston, Texas

WIND TUNNEL TEST SPECIFICS:

Test Number:	ARC 97SWT 503-1
NASA Series Number:	OS302B
Model Number:	81-Ø, 117-Ø
Test Dates:	28 August to 3 September, 1981
Occupancy Hours:	32

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ABSTRACT

An experimental investigation (OS302B) was conducted in the NASA/Ames Research Center (ARC) 9x7-foot Supersonic Wind Tunnel from August 28, 1981 through September 3, 1981. The purpose of the test was to subject large-scale specimens of Advanced Flexible Reusable Surface Insulation (AFRSI) to Space Shuttle Orbiter ascent aerodynamic pressure gradient loadings and turbulence levels for time durations equivalent to 100 missions with a scatter of four (400 missions).

The test articles were AFRSI quilted blankets of varying thicknesses, configured with a heavy or a light silica cloth covering, in patterns duplicating the joining designs to be employed on various areas of the Orbiter vehicle. All three specimens survived the full simulation times without damage.

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INTRODUCTION

Advanced Flexible Reusable Surface Insulation (AFRSI) is presently under consideration as a potential replacement for the Low-Temperature Reusable Surface Insulation (LRSI) tiles on the Space Shuttle Orbiter Vehicle. The AFRSI is a quilted blanket consisting of silica fiber felt insulation material with a quartz fabric outer mold line (OML) and a glass fabric inner mold line (IML) lining. The quilting is done with quartz thread stitched through the three layers of material. The blanket IML is bonded to the skin of the vehicle while the OML face is exposed to the high pressure gradients, fluctuating acoustic pressures, and wind shear stresses attendant to atmospheric flight. The blankets are pliable, but individual fibrous elements are hard and brittle, and susceptible to damage, especially where they cross each other. Therefore, the durability of various AFRSI configurations in the presence of turbulent airflows requires investigation.

The purpose of this test was to subject large-scale specimens of AFRSI to orbiter flight test (OFT) ascent aerodynamic pressure gradient loadings and turbulence levels for time durations equivalent to 100 missions with a scatter of four (400 missions).

The test was conducted in the NASA/ARC 9x7-foot supersonic wind tunnel from August 28, 1981 through September 3, 1981. Three runs were completed during 32 hours of occupancy.

The test articles were AFRSI quilted blankets of varying section thicknesses, two configured with a heavy silica cloth face covering and one with a light covering of the same material, applied in patterns duplicating the joining and closeout designs to be employed on the orbiter wing, the canopy area (forward of the windshield), the OMS pods, the upper elevon and vertical tail areas.

Compression corner flow characteristics with attendant flow separation and unsteady shock patterns were created at specific areas of the specimens by deflecting a flap located at the trailing edge of the pads. The test consisted of sweeping the flap deflection from 30 to 50 degrees at constant Mach number (1.8) and constant dynamic pressure (965 or 1060 psf). These conditions and the life duration times were selected from design shock pressures and local turbulence considerations related to the orbiter areas involved.

Each specimen was instrumented to measure local static pressures at the subsurface (IML) and fluctuating pressures inside the AFRSI insulation material.

This investigation was the second of a 2-phase development test program where the first phase (OS302A) was conducted in the ARC 11-foot transonic wind tunnel and was reported separately (DMS-DR-2469).

This report presents information on the conduct of the test, descriptions of the test fixture, of the specimens, and of the test facility, instrumentation particulars, and a sample of the pressure data collected during the test. Post-test pictures of the specimens are included.

NOMENCLATURE

SYMBOL	MNEMONIC	DEFINITION
C_P	CP	Pressure coefficient
DB	DB	Decibel representation pf P_{rms}
M	Mach	Freestream Mach number
P_∞	P	Freestream static pressure, psia
P_ℓ	PL	Local static pressure, psia
P_{RMS}	PRMS	RMS value of the variations from the mean value of the local pressure, psi
P_t	PT	Freestream total pressure, psia
q	Q	Freestream dynamic pressure, psf
R_e	RE	Freestream Reynolds number, per ft
T_s	TS	Freestream static temperature, ^oR
T_t	TT	Freestream total temperature, ^oR
V_∞	VEL	Freestream velocity, ft/sec
X	X	Longitudinal distance positive, inches aft of specimen frame leading edge
Y	Y	Lateral distance positive, inches right of fixture centerline
δ_F	FLAP	Test fixture flap setting, degrees
ρ	RHO	Freestream density, slugs/ft^3

NOMENCLATURE (Concluded)

Other symbology includes

AFRSI	Advanced Flexible Reusable Surface Insulation
OML	Outer Mold Line
IML	Inner Mold Line
TOC	Time on Condition

Specimen Identification

CONF	Specimen configuration ID code
A and E	Specimen pattern identification
L,H	Specimen cover fabric weight ("light" or "heavy")

REMARKS

Some difficulties were encountered with pressure tubes being plugged by loose AFRSI felt particles. Those were cleared up but the occurrence suggests that in future tests, 1/16-inch tubing should be employed in lieu of 0.40-inch tubing, in any similar instrumentation of AFRSI specimens.

Minor malfunctions of the static pressure instrumentation were experienced during the test:

1. Pressure tap 211 on the test fixture never did function properly.

2. Pressure tap 404 on specimen 3E-H was defective as were taps 404 and 603 on specimen 1A-L.

In order to effect savings in operating costs, the specified test time of 50 minutes for specimen 3E-H was accumulated in two segments of 24 and 26 minutes.

All test objectives were met and the three specimens tested survived the full simulation times without damage. Post-test photographs of these specimens are shown in Figures 8a. through 8c.

CONFIGURATIONS INVESTIGATED

Model Description

Model 81-Ø (drawing L014-01496) as modified in June 1981 for test OS304B, was employed for this test. The fixture, located in the ceiling of the tunnel, consists of a 12-inch chord flap with a 100-inch span, mounted at the trailing edge of a specimen-holding frame, and a sealed pressure box enclosing the space above the holding frame. The pressure box was vented to the tunnel test section to permit pressure equalization across the test pads.

Deflection of the hydraulically actuated flap produces an upstream pressure disturbance which results in a thickening of the boundary layer. This in turn, deflects the flow from its original direction and creates a reverse flow region near the boundaries in the flap/surface corner. In the area where boundary separation occurs, an unsteady shock wave is formed which gives rise to a large step-type positive pressure gradient and high turbulence levels (see Figure 2). The shape of the pressure distribution and the values of the pressure coefficients (shock strength) in the region of the separation depend on both Mach number and Reynolds number. For a given combination of these two numbers, the flow separation point is determined by the flap angle. For this test, Mach and q were selected to yield shock strengths of 1.79 and 2.11 psi.

A 4.5-inch spacer was used together with shims to bring the leading and trailing edges of the specimen pads flush with the surface of the test fixture. The spacer/shim combinations employed are shown schematically in Figure 3. These were intended to compensate for the 6.77-inch depth of the supporting frame inside the test fixture.

Test Specimens

The AFRSI blankets consist of silica fiber felt (Q-felt) insulation material with a silica cloth covering and a glass cloth back lining, all quilted together with quartz thread in a one-inch square grid pattern. The quilting is done with a modified lock stitch. The outer covering is made of either of two fabric weights: a "light-cover" which is 0.010 inch thick (7 oz./sq.yard) or a 0.027-inch "heavy cover" (20 oz./sq. yard).

The test pads consisted of framed AFRSI panels (40x24 inches) bonded with RTV to 3/4-inch aluminum support plates (43.0 x 27.5 inches), so that the stitching loops were imbedded in the bonding material. One-inch wide rectangular wooden frames surrounded the AFRSI material. The frame/specimen interfaces were closed off with aluminum strips which covered the top surface of the frames and extended one inch over the AFRSI material, leaving an exposed AFRSI surface of 36x20 inches. The cover strip extensions were bonded to the top of the specimen material to prevent puffing and possible damage to the blankets. The leading edge thickness of the assembled test pads varied from 1.220 to 1.622 inches. A sketch of a test specimen assembly is shown in Figure 4.

The same alphanumeric scheme (e.g., 3E-H) was employed to identify all the specimens tested in both OS302A and B. The first numeral designated the total configuration. Each of the joining patterns was denominated by a letter from A to E. The last letter identified the type of face covering on the specimen: light (L) or heavy (H) cover. A listing of the OS302B specimen identifications together with the orbiter areas each represents is shown in Table I. Sketches of the pattern layouts are shown in Figure 5. The test specimens are described in detail in drawings VT70-095014 and VT70-095016 (Reference 1).

This group of three test pads together with the nine that were tested in OS302A was designated model 117-Ø.

INSTRUMENTATION

The model test fixture and all the specimens were instrumented with static pressure taps and fluctuating pressure transducers. The layouts together with the nominal and actual location coordinates of the instrumentation are shown in Tables II and III and in Figure 6.

Static Pressure

The test fixture was instrumented with 24 static pressure taps: 16 on one side and 8 on the other.

Specimen instrumentation was dependent on the pattern layout: 1A-L and 4A-H were each equipped with 35 taps while specimen 3E-H was instrumented with 36. These taps consisted of 0.040-inch OD steel tubing passed through the support plates and protruding above the RTV bonding to the subsurface of the AFRSI material, always penetrating all bond lines.

Fluctuating Pressure

The test fixture was instrumented with six Kulite transducers to measure peripheral fluctuating pressures. Each specimen was also equipped with the same number of Kulites. These were installed to protrude approximately 1/4 inch above the RTV bond line, into the felt insulation material.

TEST FACILITY DESCRIPTION

The 9x7-Foot Supersonic Wind Tunnel is one of the supersonic legs of the Ames Unitary facility. It is a closed-circuit, variable-density, continuous-flow tunnel. The test section is 9 feet wide by 7 feet high by 18 feet long and the nozzle is of the asymmetric, sliding-block type, in which the variation of the test section Mach number is achieved by translating, in the streamwise direction, the fixed contour block that forms the floor of the nozzle. The temperature is controlled by after-cooling. Dry air for use in the circuit is supplied from four 30,000 cubic-foot spherical tanks. The tunnel drive motors and compressor also serve the 8 by 7-foot tunnel. The motors have a combined output of 180,000 horsepower for continuous operations or 216,000 horsepower for one hour of operation.

TEST PROCEDURES

All testing was conducted at a constant Mach number of 1.8 and constant dynamic pressure (965 or 1060 psf). After setting the tunnel conditions, the trailing edge flap on the fixture was deflected to 30 degrees and held at that angle for two minutes. The flap angle was then increased by five degrees and held in this new position for the same length of time. This procedure was repeated for each flap angle up to 50 degrees. After completing this first flap angle sweep, the flap was returned to 30 degrees and a second cycle similar to the first was started. The procedure was repeated until the total test time specified for the specimen was accumulated.

A summary of the runs completed including the test conditions and the time-on-condition for each specimen is shown in Table IV.

DATA REDUCTION

Standard tunnel equations were used to compute all tunnel conditions.

Local static pressure data were reduced to standard coefficient form,

$$C_p = (P_\ell - P_\infty) \times 144/q$$

RMS fluctuating pressure data were reduced to coefficient form and to DB form,

$$DB = 10 \log_{10} \left[\frac{P_{RMS} \times 10^9}{2.9007} \right]^2$$

These data were recorded continuously on magnetic tape and analyzed by Rockwell's Vibration and Acoustics unit (Dept. 380).

A typical data output printout is shown in Figures 7a. through 7e.

REFERENCES

1. STS81-0539, "Pretest Information for the AFRSI Full-Scale Development Tests OS302A/B in the Ames Research Center (ARC) 11x11-Ft. and 9x7-Ft. Wind Tunnels Using Model 117-0 Installed in Model 96-0 and 81-0 Fixtures," September 1981.

TABLE I

MODEL 117-0 TEST SPECIMEN IDENTIFICATION OS302B

CONF.	PATTERN (1)	COVER FABRIC WEIGHT	ORBITER AREA(S)	DETAIL DWG.
1	A	L	WING; ELEVON; V-TAIL	VT70-095016
3	E	H	CANOPY (FWD); OMS	VT70-095014
4	A	H	WING; ELEVON; V-TAIL	VT70-095016

L: LIGHT COVER (7 OZ/SQ YARD)

H: HEAVY COVER (20 OZ/SQ YARD)

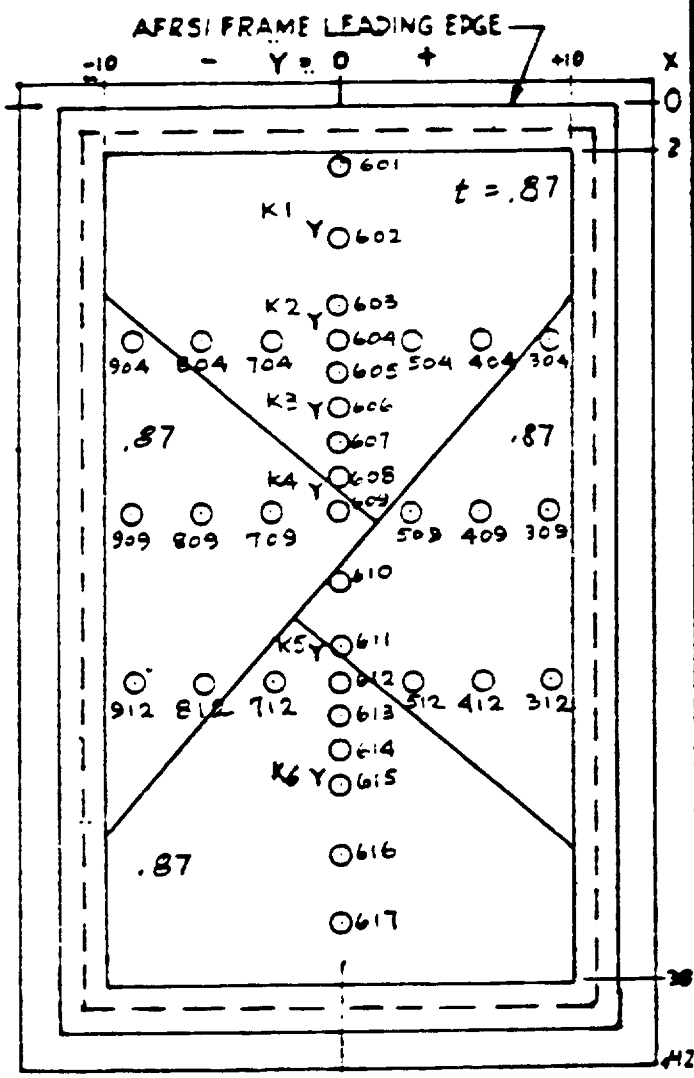
(1): SEE FIGURE 5, (DWG. SK-0S302-1)

TABLE II. INSTRUMENTATION LOCATION, MODEL 81-0 FIXTURE OS302B

X, in. \ Y, in.	-14.62	14.62
	STATIC TAPS	
2	101	201
6	103	203
10	105	205
12		207
14	109	209
16		211
18	113	213
20		215
22	117	217
24		219
26	121	221
28		222
30		224
32		225
34		227
36	128	228
	KULITES	
5		K21
9		K22
13		K24
17		K26
23		K29
29		K31

TABLE III. INSTRUMENTATION LOCATION, MODEL 117-0 SPECIMENS

SPECIMEN	PATTERN	FIXTURE	TUNNEL
1	A-L	81-0	9×7



STATIC TAP NO.	NOMINAL COORDINATES X	NOMINAL COORDINATES Y	ACTUAL COORDINATES X	ACTUAL COORDINATES Y
304	10.0	9.0	9.9	8.9
309	17.5		17.4	9.1
312	25.0		25.1	9.1
404	10.0	6.0	9.9	6.2
409	17.5		17.6	6.3
412	25.0		25.0	5.8
504	10.0	3.0	10.0	3.3
509	17.5		17.5	3.2
512	25.0		25.0	2.9
601	2.5	0.0	2.4	0.0
602	5.5		5.4	-0.2
603	8.5		8.4	0.0
604	10.0		9.9	0.0
605	11.5		11.3	0.0
606	13.0		12.7	0.1
607	14.5		14.6	0.0
608	16.0		16.0	0.0
609	17.5		17.4	0.3
610	20.5		20.4	0.0
611	23.5		23.4	0.0
612	25.0		25.4	-0.1
613	26.5		26.7	-0.1
614	28.0		28.1	0.1
615	29.5		29.7	0.0
616	32.5		32.6	0.2
617	35.5		35.4	0.3
704	10.0	-3.0	10.0	-3.0
709	17.5		17.2	-3.0
712	25.0		25.0	-2.5
804	10.0	-6.0	10.2	-5.9
809	17.5		17.3	-6.0
812	25.0		25.0	-6.0
904	10.0	-9.0	9.9	-8.8
909	17.5		17.5	-9.0
912	25.0		25.1	-8.7

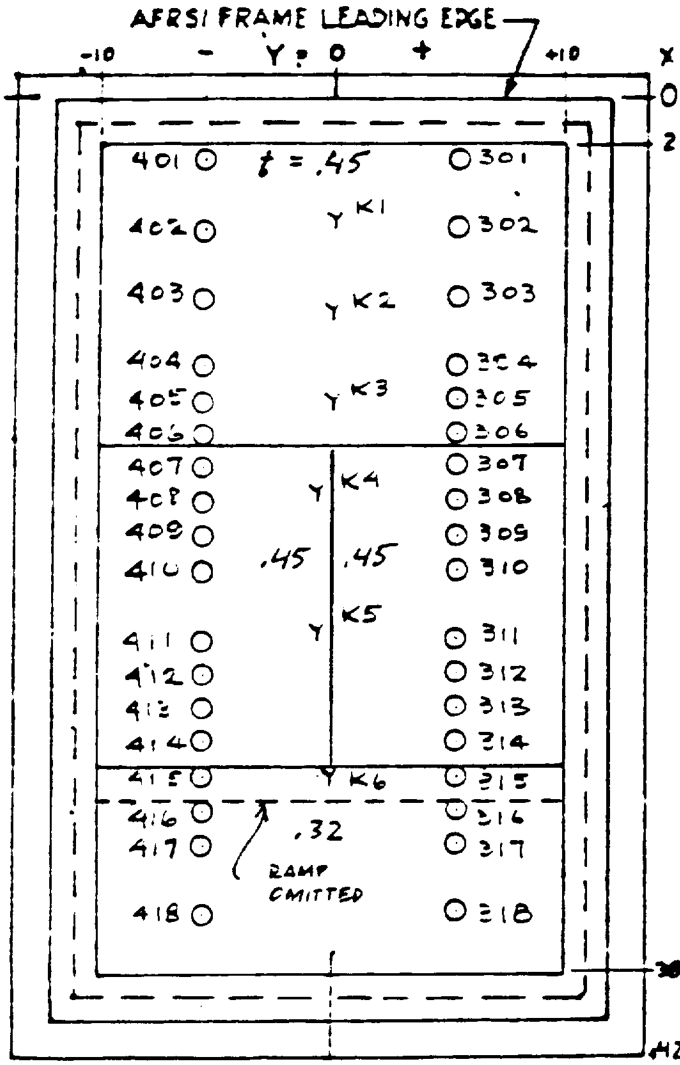
KULITE LOCATIONS

NUMBER	NOMINAL X	NOMINAL Y	ACTUAL X	ACTUAL Y
K1	5	-0.75	4.9	-0.9
K2	9		9.1	-0.75
K3	13		13.2	-0.7
K4	17		17.4	-0.7
K5	23.5		23.4	-0.75
K6	29		29.0	-0.7

O SUBSURFACE Y KULITE

TABLE III. (Continued)

SPECIMEN	PATTERN	FIXTURE	TUNNEL
3	E-H	81-0	9x7



STATIC TAP NO.	NOMINAL COORDINATES X	NOMINAL COORDINATES Y	ACTUAL COORDINATES X	ACTUAL COORDINATES Y
301	2.5	5.5	2.5	5.5
302	5.5		5.5	5.5
303	8.5		8.5	5.5
304	11.5		11.5	5.4
305	13.0		13.3	5.4
306	14.5		14.3	5.5
307	16.0		15.7	5.6
308	17.5		17.6	5.6
309	19.0		18.7	5.6
310	20.5		20.6	5.5
311	23.5		23.5	5.5
312	25.0		24.8	5.5
313	26.5		26.5	5.5
314	28.0		27.3	5.5
315	29.5		29.5	5.5
316	31.0		31.0	5.5
317	32.5		32.5	5.5
318	35.5		35.5	5.5
401	2.5	-5.5	2.4	-5.5
402	5.5		5.3	-5.5
403	8.5		8.4	-5.5
404	11.5		11.5	-5.5
405	13.0		13.2	-5.6
406	14.5		14.2	-5.6
407	16.0		15.6	-5.5
408	17.5		17.5	-5.5
409	19.0		18.7	-5.5
410	20.5		20.5	-5.5
411	23.5		23.4	-5.5
412	25.0		24.7	-5.5
413	26.5		26.5	-5.5
414	28.0		27.7	-5.6
415	29.5		29.5	-5.5
416	31.0		31.0	-5.5
417	32.5		32.5	-5.5
418	35.5		35.5	-5.5

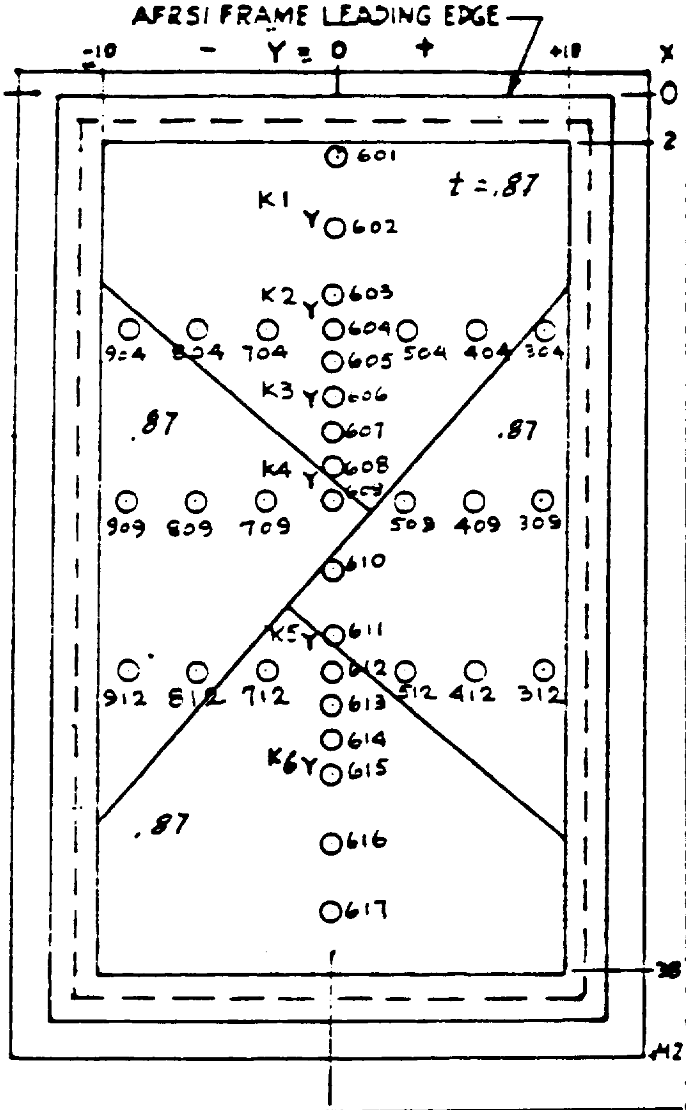
KULITE LOCATIONS

NUMBER	NOMINAL X	NOMINAL Y	ACTUAL X	ACTUAL Y
K1	5	0	5.2	.2
K2	9	0	9.2	.2
K3	13	0	13.1	.2
K4	17	-0.75	16.7	.3
K5	23	-0.75	22.7	.2
K6	29.5	0	29.5	0

○ SUBSURFACE Y KULITE

TABLE III. (Concluded)

SPECIMEN	PATTERN	FIXTURE	TUNNEL
4	A-H	81-0	9×7



STATIC TAP NO.	NOMINAL COORDINATES		ACTUAL COORDINATES	
	X	Y	X	Y
304	10.0	9.0	10.1	9.2
309	17.5		17.5	9.0
312	25.0		25.4	9.0
404	10.0	6.0	10.1	6.2
409	17.5		17.4	5.7
412	25.0		25.1	5.7
504	10.0	3.0	9.9	2.7
509	17.5		17.5	2.6
512	25.0		25.4	2.9
601	2.5	0.0	2.3	-.2
602	5.5		5.1	0
603	8.5		8.7	-.3
604	10.0		10.0	-.3
605	11.5		11.5	0
606	13.0		12.9	0
607	14.5		14.4	0
608	16.0		16.1	0
609	17.5		17.4	0
610	20.5		20.5	0
611	23.5		23.5	-.2
612	25.0		25.1	.3
613	26.5		26.6	.3
614	28.0		28.1	.3
615	29.5		29.5	.4
616	32.5		32.9	.2
617	35.5		35.8	.3
704	10.0	-3.0	10.2	-3.0
709	17.5		17.6	-2.7
712	25.0		24.6	-3.0
804	10.0	-6.0	10.0	-6.4
809	17.5		17.5	-6.1
812	25.0		25.1	-6.2
904	10.0	-9.0	9.8	-8.9
909	17.5		17.5	-9.0
912	25.0		25.1	-9.1

KULITE LOCATIONS

NUMBER	NOMINAL		ACTUAL	
	X	Y	X	Y
K1	5	-0.75	5.2	-1.1
K2	9		9.3	-.9
K3	13		13.4	-.6
K4	17		16.8	-.6
K5	23.5		23.8	-1.0
K6	29		28.8	-.4

O SUBSURFACE Y KULITE

TABLE IV

OS302B RUN SUMMARY - AFRSI
LARGE-SCALE DEVELOPMENT TEST
ARC 9x7

CONFIGURATION	M	Q psf	TIME ON COND		FLAP DEFLECTION DEG					
			PLANNED	ACTUAL	30	35	40	45	50	
1A-L	1.8	965	32	32	3					RUN NUMBERS
3E-H	1.8	1060	50	50	2					
4A-H	1.8	965	32	32	4					

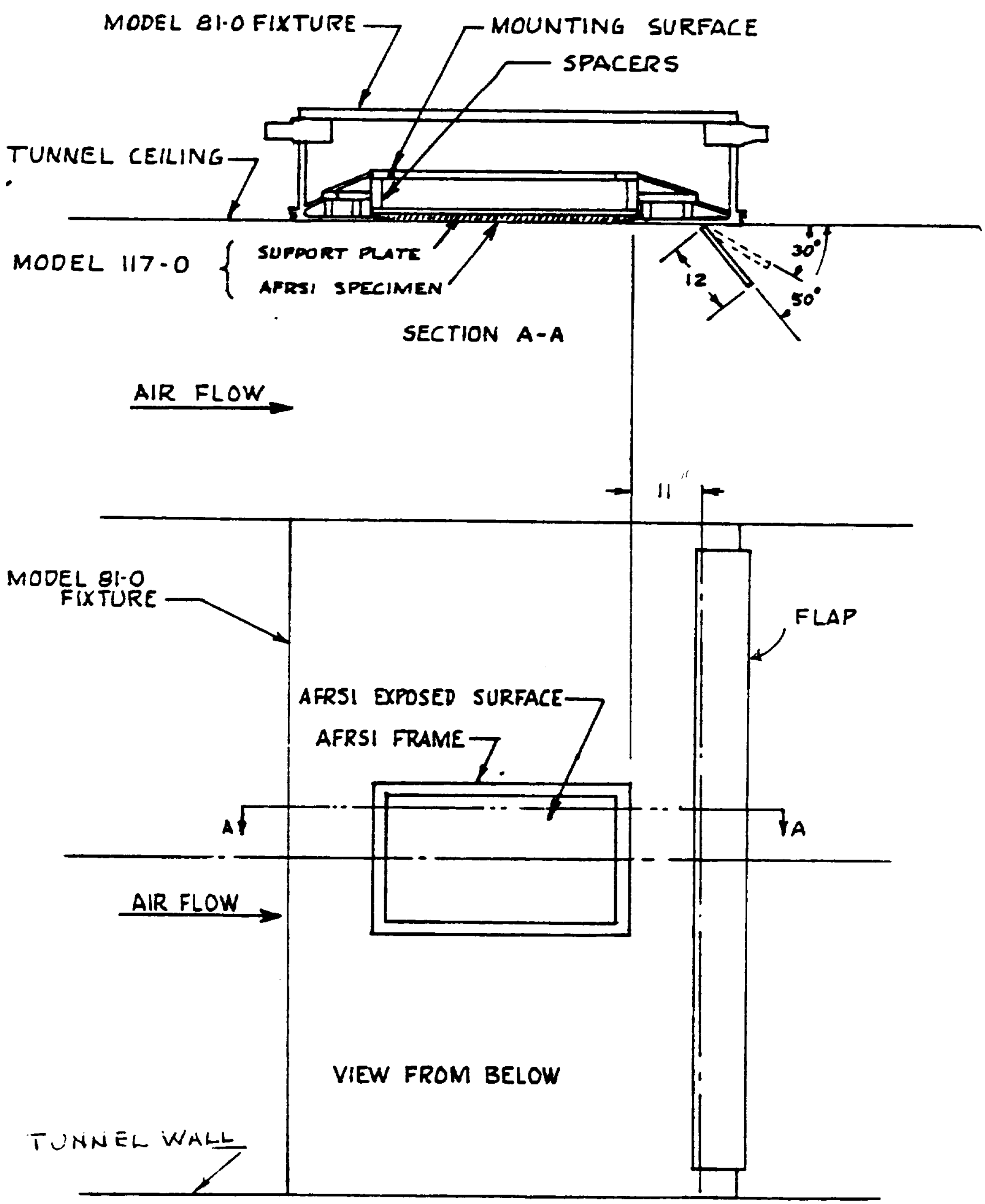


FIGURE 1. MODEL 81-Ø TEST FIXTURE, GENERAL ARRANGEMENT (OS302B)

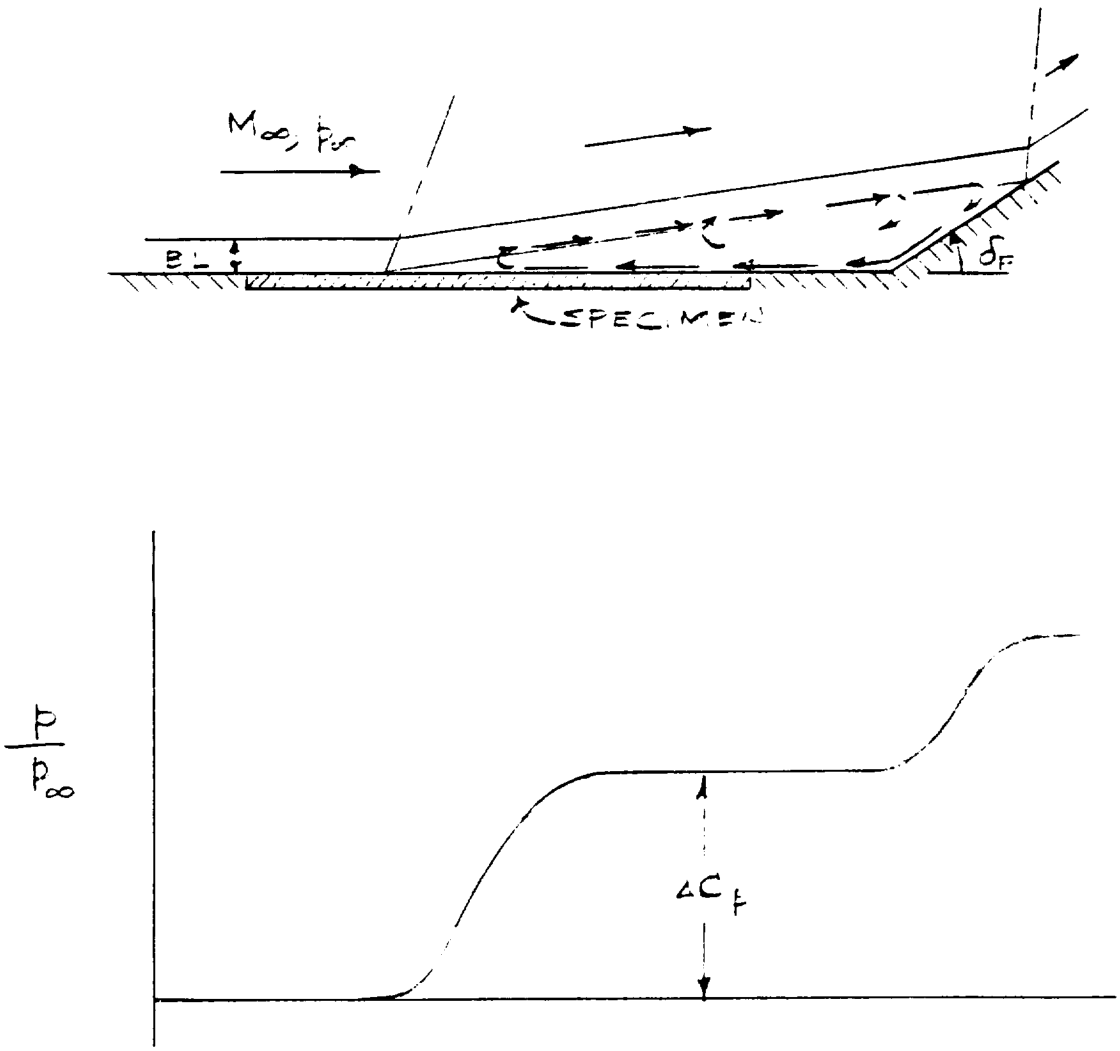


FIGURE 2. TYPICAL FLOW FIELD AND PRESSURE DISTRIBUTION (MODEL 81-Ø)

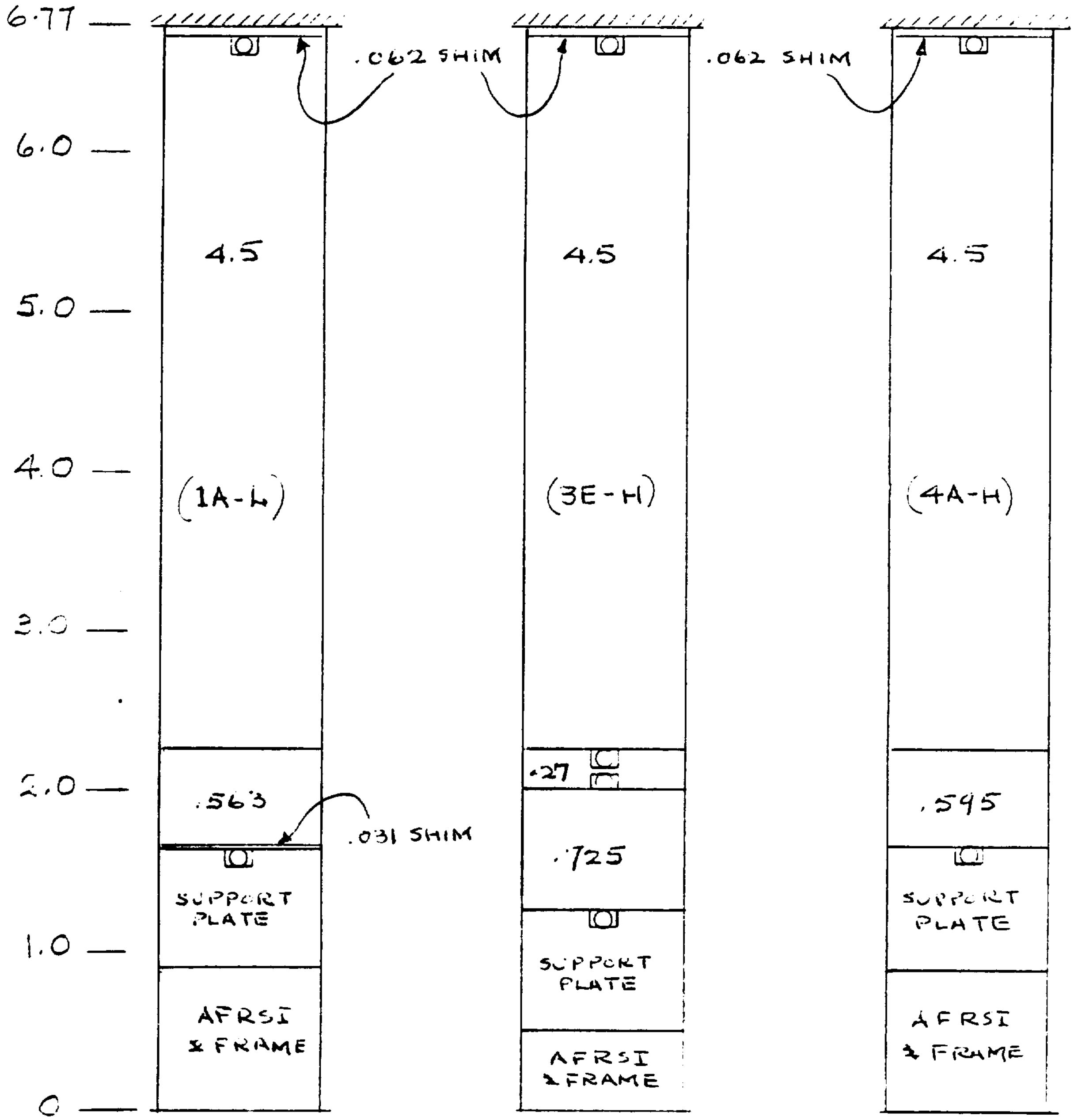
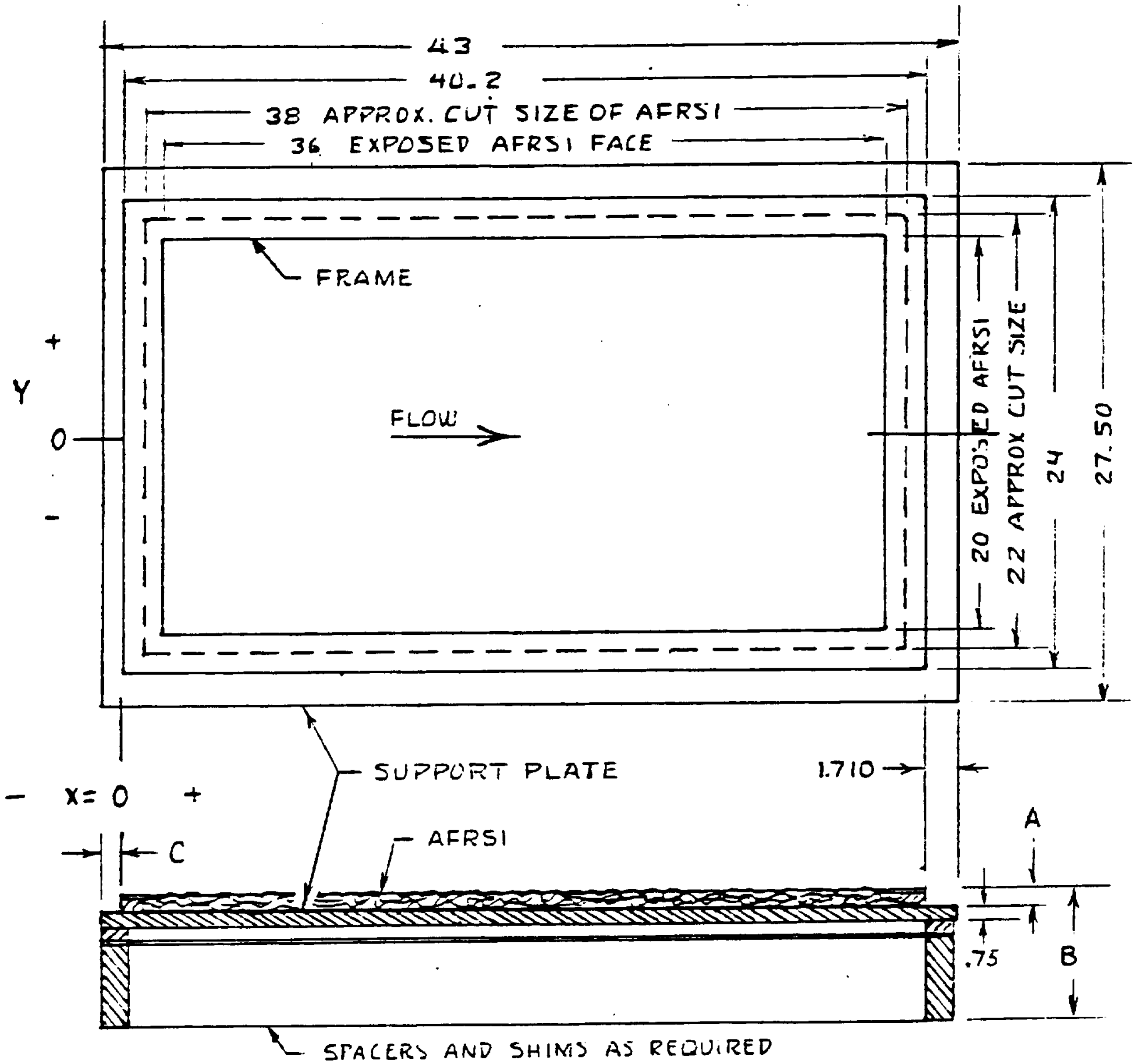


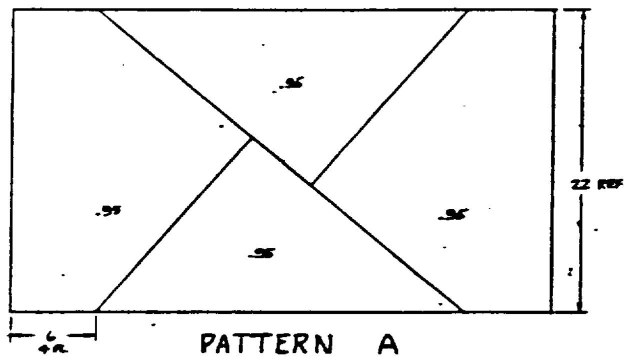
FIGURE 3. SPACER/SHIMS ARRANGEMENTS (OS302B)

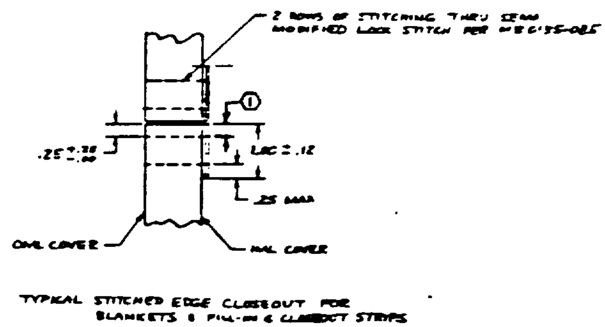


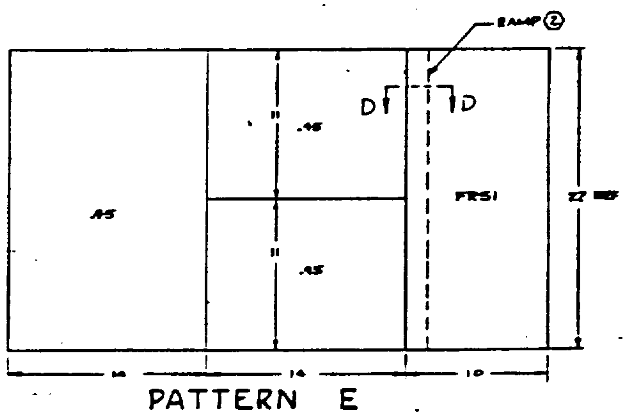
DIMENSION "A" VARIES FROM APPROX .45 TO .87.
"B" IS 6.77 INCHES

"C": THE L.E. OF THE SUPPORT PLATE IS 1.05
AHEAD OF STA. X=0.
THE L.E. OF THE AFRSI FRAME IS AT X=0.

FIGURE 4. MODEL 117-Ø AFRSI TEST SPECIMEN ASSEMBLY







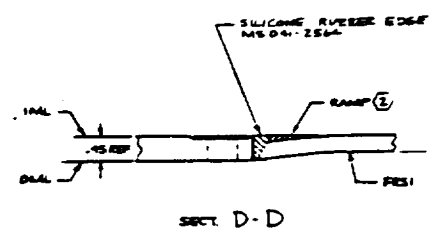


FIGURE 5. SPECIMEN PATTERN LAYOUT SKETCHES

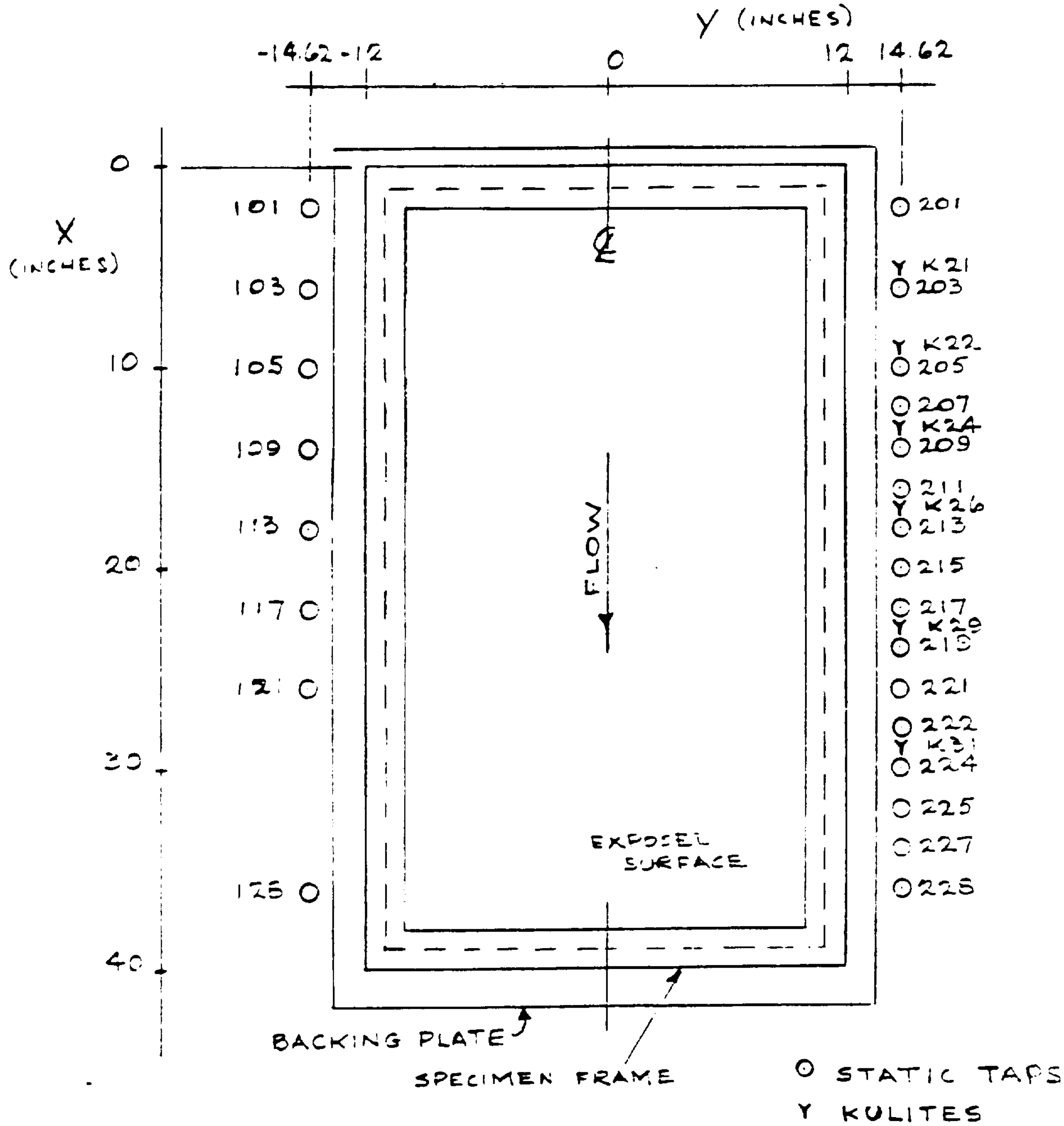


FIGURE 6. INSTRUMENTATION LOCATION, MODEL 81-0 FIXTURE (OS302B)

```
TST-503 PH-1 TP-97  2121          ID=PRESSOUTC          03 SEP 81633108        PAGE  19

    RUNISEL
     2121

  MACH     CCNF      Q         BT        P         RE       TTH      RHO        FLAP     DATE    TIME    PAD
 1.800       3     1059.2    2683.4    467.0     4.479    601.6   0.000745    30.79    9011    351

            1        2        3        4        5        6        7       8        9        10       11       12
 PRMS     0.00     0.01     0.01     0.01     0.00     0.05     0.03    0.00     0.02     0.00     0.01     0.05

 CP      124.7    129.1    130.0    129.3    123.5    144.4    139.1  -158.6    137.7   -128.1    129.6    145.3

   1        2        3        4        5        6        7        8        9       10       11       12       13       14       15       16       17       18
-0.035   0.029   0.013  -0.000   0.032   0.009  -0.006   0.003   0.025   0.009  -0.005   0.021   0.043   0.076   0.114   0.139   0.158   0.187

-0.051   0.036   0.041A*******   0.053   0.084   0.011  -0.003   0.021   0.009   0.006   0.026   0.054   0.098   0.135   0.154   0.165   0.188


    2        6       10       12       14       16       18       20       22       24       26       28       30       32       34       36
 0.010    0.022    0.006    0.010    0.003    0.014  50.003    0.007    0.002    0.012    0.009    0.017    0.051    0.170    0.234    0.272

 0.002  -0.001    0.007             0.001             0.020             0.005             0.002                                        0.273
AIRTSAVO2C     OUT OF RANGE.
```

FIGURE 7a. TYPICAL DATA OUTPUT (OS302B)

```
TST-503 PH-1 TN-97  2122            ID=PRESSURTO          03 SEP 81,023108        PAGE  2C
    RUNISEQ
     2122

 MACH     CONF      Q          PT          P         RE         TTR        RHO          PLAP      DATE      TIME      PAD
 1.800      3     1058.6     2682.0      466.8      4.45        603.3     0.000743      35.68     9011      .353

 PRMS      1         2          3          4          5          6          7          8          9          10         11         12
          0.01      0.01       0.01       0.01       0.03       0.08       0.03       0.01       0.02       0.00       0.09       0.04

 TP      125.8     131.6      128.6      125.4      139.1      148.3      139.4      130.1      137.7     -130.0      149.6      142.1

    1        2        3        4        5        6        7        8        9        10       11       12       13       14       15       16       17       18
 -0.033   0.032    0.014    0.001    0.032    0.005   -0.006    0.008    0.029    0.020    0.088    0.146    0.194    0.226    0.251    0.254    0.265    0.283
 -0.050   0.039    0.042A*******      0.052    0.084    0.012    0.001    0.027    0.041    0.126    0.195    0.208    0.236    0.255    0.262    0.264    0.281

    2        6        10       12       14       16       18       20       22       24       26       28       30       32       34       36
 0.010    0.023    0.006    0.012    0.005    C.C      -0.003   0.004    0.004    0.020    0.092    0.199    0.249    0.277    0.294    0.322
 0.003    0.001    0.009             0.001             0.021             0.012             0.125                                           0.304
AIRTSAV020   OUT OF RANGE.
```

FIGURE 7b. TYPICAL DATA OUTPUT (OS302B)

TST-503 PH-1 TN-97 2123 ID=PRESSOUTO 08 SEP 8[illegible]3108 PAGE 21

RUNISEQ
2123

MACH	CONF	Q	PT	P	RE	TTR	RHO	FLAP	DATE	TIME	PAD
1.800	3	1057.5	2679.1	460.3	4.43X	604.7	0.000741	40.71	0011	359	

	1	2	3	4	5	6	7	8	9	10	11	12
PRMS	0.00	0.01	0.01	0.01	0.11	0.08	0.03	0.00	0.02	0.00	0.04	0.04
CA	123.3	127.5	126.8	134.1	181.9	149.2	140.0	-136.6	136.9	-142.0	143.7	143.2

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	CP.030	0.033	0.016	0.003	0.033	0.010	0.009	0.021	0.106	0.179	0.235	0.261	0.277	0.293	0.310	0.285	0.317	0.330
	CP.051	0.038	0.042********		0.057	0.092	0.052	0.049	0.134	0.194	0.232	0.262	0.273	0.289	0.310	0.318	0.313	0.326

2	6	10	12	14	16	18	20	22	24	26	28	30	32	34	36
0.011	0.025	0.008	0.011	0.005	$\cancel{0.0??}$	0.000	0.024	0.124	0.219	0.258	0.284	0.303	0.321	0.334	0.354
0.002	0.001	0.009		0.003		0.037		0.188		0.258					0.328

AIRTSAV02C OUT OF RANGE.

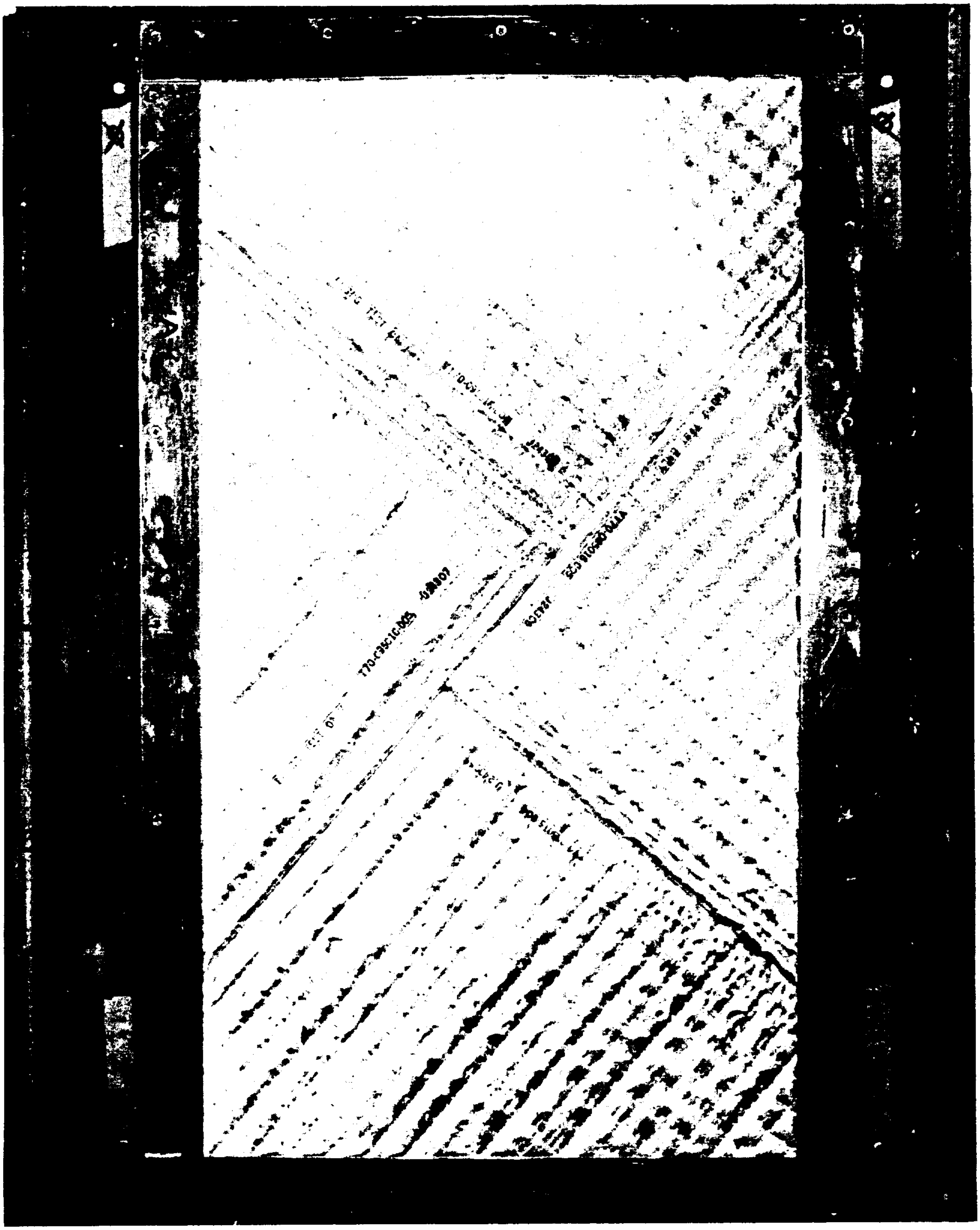
FIGURE 7c. TYPICAL DATA OUTPUT (OS302B)

```
TST-503 PH-1 TN-97  2124          ID-PRESSOUTO          05 SEP 8;653108        PAGE  22

     RUNISEQ
      2124

 MACH     CONF      Q        PT        P        RE       TTR       RHC        FLAP    DATE    TIME    PAD
 1.800      3    1058.1   2680.6    466.5    4.434    605.0    0.000741     45.61   9011     387

           1        2        3        4        5        6        7        8        9       10      11      12
 PRMS    0.00     0.01     0.02     0.18     0.08     0.09     0.02     0.01     0.06     0.00    0.08    0.04

 CR     124.7    128.3    136.1    155.6    148.5    180.2    138.6    139.8    146.0   -182.5   143.9   143.0

   1       2       3       4       5       6       7       8       9      10      11      12      13      14      15      16      17      18
 0.030   0.034   0.016   0.008   0.066   0.080   0.182   0.198   0.226   0.268   0.295   0.314   0.322   0.335   0.350   0.351   0.354   0.365
 0.051   0.040   0.043A******    0.103   0.143   0.185   0.198   0.229   0.267   0.289   0.310   0.320   0.333   0.354   0.356   0.352   0.363



   2       6      10      12      14      16      18      20      22      24      26      28      30      32      34      36
 0.011   0.024   0.008   0.012   0.006   0.051   0.146   0.233   0.265   0.297   0.305   0.323   0.339   0.350   0.350   0.381

 0.002   0.001   0.008           0.011           0.192           0.274           0.306                                   0.384
AIRTSAV020     OUT OF RANGE.
```

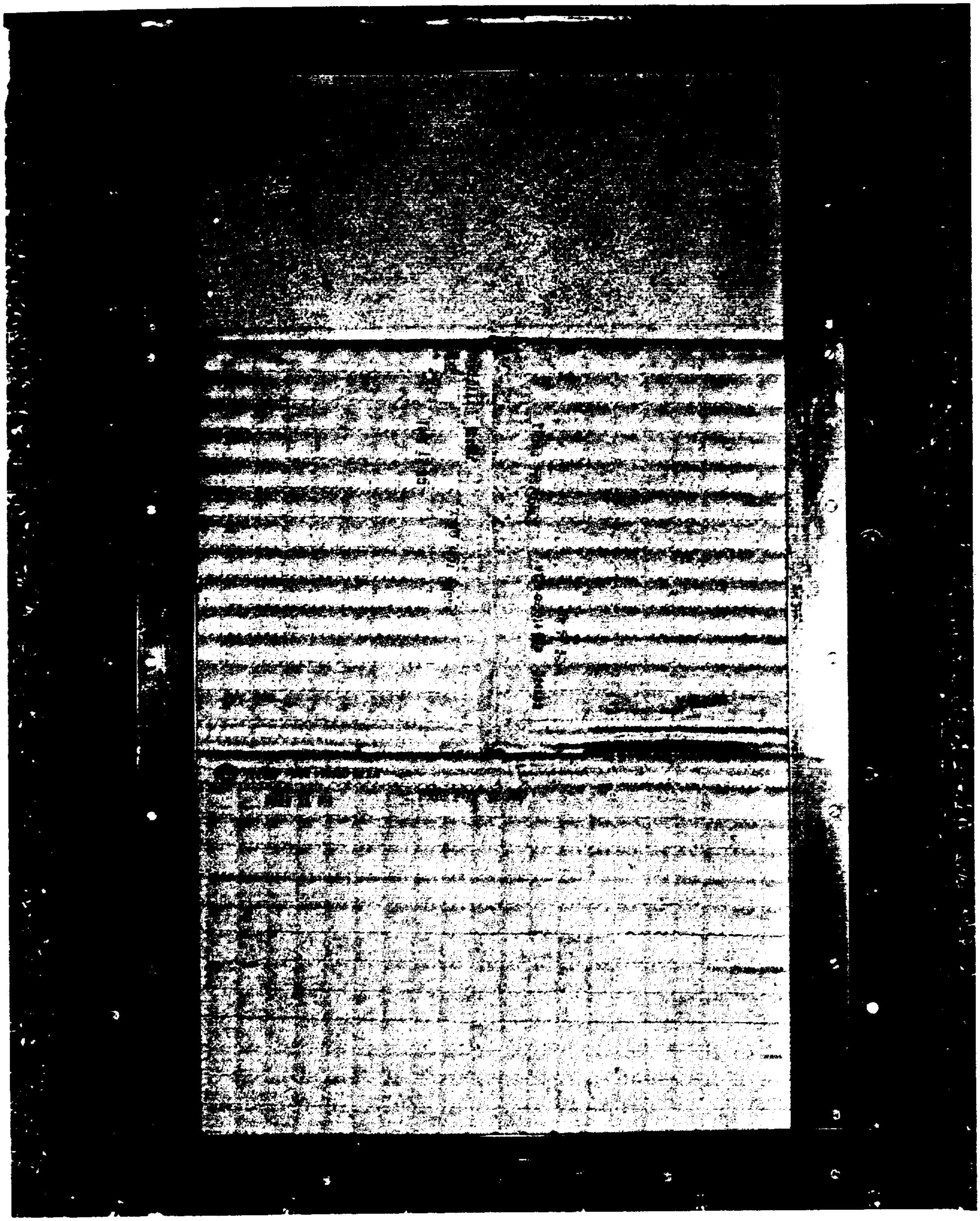
FIGURE 7d. TYPICAL DATA OUTPUT (OS302B)

```
TST-503 PH-1 TN-97  2125          ID-PRESSURE          03 SEP 81 133105       PAGE  23

    RUNISEQ
     2125

 MACH     CONF      Q         BT         P         RE        TTR       RHO        FLAP      DATE      TIME     PAD
 1.800      3     1058.4    2681.3     460.6     4.420     605.7    0.000140    31.25     0011      359

           1         2         3         4         5         6         7         8         9        10        11        12
 RAMS    0.01      0.12      0.14      0.09      0.09      0.10      0.04      0.13      0.06      0.00      0.05      0.04

 TR     131.3     152.1     153.5     150.0     149.8     150.7     142.1     153.2     146.9    -132.5     145.1     142.5

   1        2        3        4        5        6        7        8        9        10       11       12       13       14       15       16       17       18
 -0.031   0.039    0.085    0.208    0.348    0.273    0.275    0.302    0.317    0.348    0.354    0.369    0.375    0.383    0.400    0.382    0.401    0.409
 -0.051   0.042    0.096*******      0.341    0.209    0.276    0.309    0.322    0.348    0.354    0.371    0.375    0.381    0.401    0.404    0.401    0.408




   2        6        10       12       14       16       18       20       22       24       26       28       30       32       34       36
 0.012    0.024    0.039    0.201    0.252    0.296    0.310    0.347    0.341    0.360    0.350    0.375    0.400    0.394    0.402    0.415
 0.001    0.001    0.088             0.196             0.298             0.339             0.361                                         0.408
AINTSAV02C      OUT OF RANGE.
```

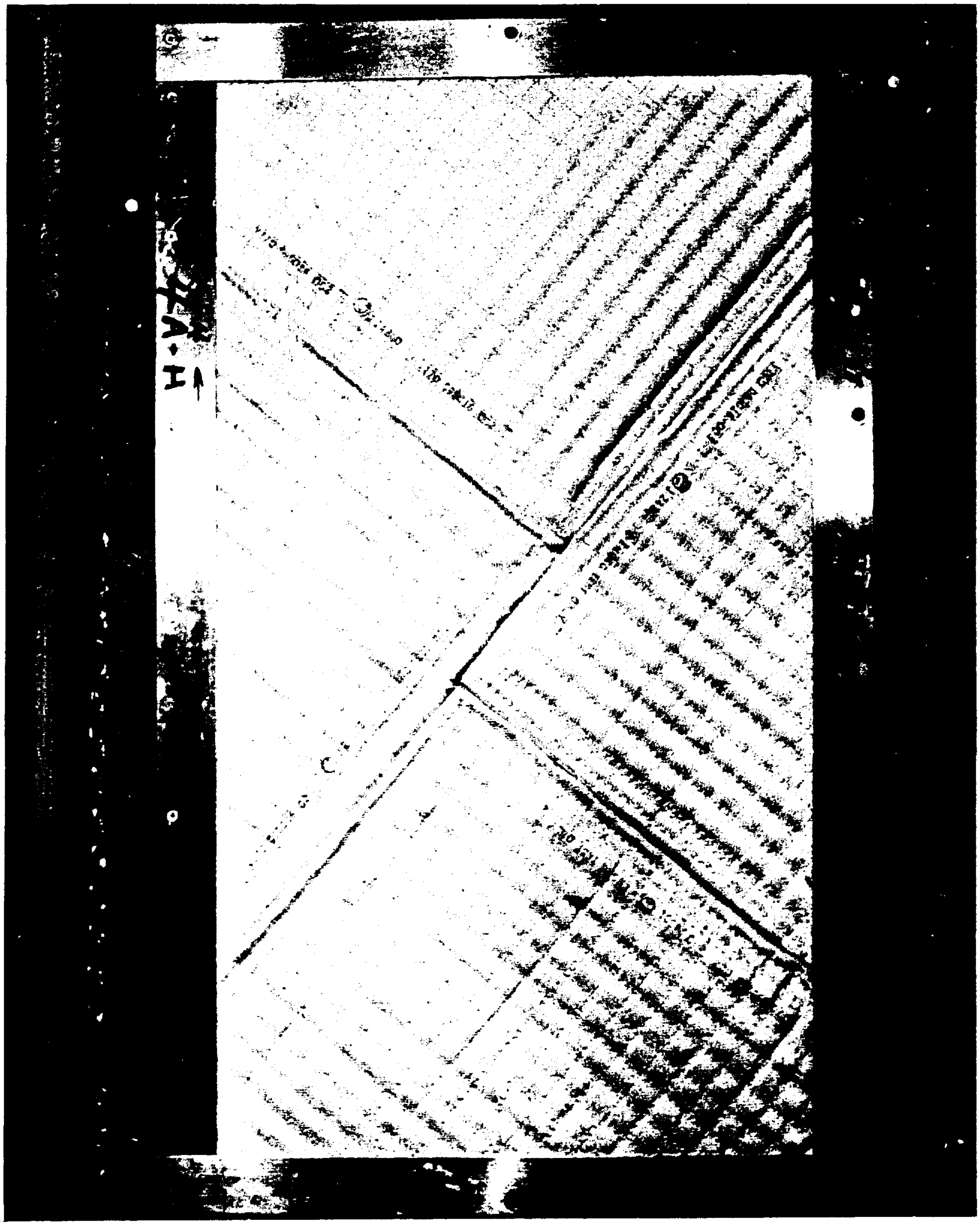
FIGURE 7e. TYPICAL DATA OUTPUT (OS302B)



a. Specimen 1A-L, Run 3
Figure 8. Post-Test Photographs of AFRSI Specimens



b. Specimen 3E-H, Run 2
Figure 8. (Continued)



c. Specimen 4A-H, Run 4
Figure 8. (Concluded)